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User's Manual of Interactive Software for Predicting CPF Bow-Flare Impulsive Loads

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Contract Number: W7707-021328/001/HAL

Contract Scientific Authority: Kevin McTaggart, (902) 426-3100 ext. 325

The scientific or technical validity of this Contractor Report is entirely the responsibility of the contractor and the contents do not necessarily have the approval or endorsement of Defence R&D Canada.

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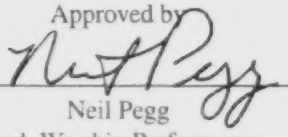
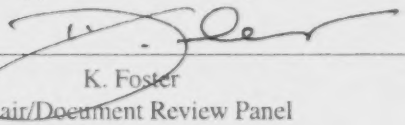
Approved by



Neil Pegg
Head, Warship Performance

Approved for release by



K. Foster
Chair/Document Review Panel

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Abstract

Based on the theoretical background, the numerical scheme and computational result for predicting CPF bow-flare impulsive loads, an interactive software package, namely, *CPFSLAM*, is developed. This package fully utilizes the special features of Qt (GUI-toolkits) and OpenGL (3-D rendering library). The software can predict flow and pressures arising from slamming of two-dimensional sections of the HALIFAX class. The software includes a three-dimensional NURBS representation of the HALIFAX class, from which the user can select a two-dimensional section of interest for slamming calculations.

Résumé

Fondé sur l'explication théorique, le shéma numérique et le résultat des calculs pour prédire les contraintes impulsives créées par l'effet de gifle sur le redan de proue des frégates canadiennes de patrouille, un logiciel interactif, nommément CPFSLAM, est en cours de développement. Ce logiciel exploite les caractéristiques spéciales de Qt (boîtes à outils GUI) et d'OpenGL (bibliothèque de présentation en 3 dimensions). Ce logiciel peut prédire l'écoulement et les pressions créés par l'effet de gifle sur des sections bidimensionnelles des navires de la classe HALIFAX. Il comprend une représentation NURBS à 3 dimensions des navires de cette classe, à partir de laquelle l'exploitant peut choisir une section d'intérêt transversale à 2 dimensions pour les calculs des effets de gifle.

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Executive summary

Introduction

Slamming forces must be considered for the safe design and operation of naval vessels. For frigate hull forms, bow-flare slamming can induce significant loads. This report describes software for predicting flow and pressures arising from bow-flare slamming. A separate report describes the theory for the slamming prediction method.

Principal Results

The software can predict flow and pressures arising from slamming of two-dimensional sections of the HALIFAX class. The software includes a three-dimensional NURBS representation of the HALIFAX class, from which the user can select a two-dimensional section of interest for slamming calculations.

Significance of Results

The developed software appears to be promising for predicting bow-flare slamming on two-dimensional ship sections. Validation with experimental data and examination of required computational times are recommended for the developed software.

Future Plans

Ongoing work is considering different methods for incorporating slamming into ship motion and sea load predictions.

J.M. Chuang and Qin Tu; 2004; User's Manual of Interactive Software for Predicting CPF Bow-Flare Impulsive Loads; DRDC Atlantic CR 2004-183; Defence R&D Canada – Atlantic.

Sommaire

Introduction

Il faut tenir compte des forces d'effet de gifle pour concevoir et exploiter des navires de guerre en toute sécurité. Dans le cas des formes de coque des frégates, l'effet de gifle sur le redan de la proue peut créer des contraintes importantes. Le présent rapport décrit le logiciel permettant de prédire l'écoulement et les pressions créées par ce phénomène. Un autre rapport décrit la théorie de la méthode de prédiction des effets de gifle.

Résultats principaux

Ce logiciel peut prédire l'écoulement et les pressions résultant des effets de gifle sur des sections à 2 dimensions des navires de la classe HALIFAX. Il comprend une représentation NURBS à 3 dimensions des navires de cette classe, à partir de laquelle l'exploitant peut choisir une section d'intérêt transversale à 2 dimensions pour les calculs des effets de gifle.

Importance des résultats

Le logiciel mis au point semble être prometteur pour la prédiction de l'effet de gifle sur le redan de la proue sur des sections à 2 dimensions du navire. On recommande une validation avec des données expérimentales et un examen des durées de calcul nécessaires pour ce logiciel.

Travaux ultérieurs prévus

Les travaux en cours envisagent diverses méthodes pour incorporer les effets de gigle sur les mouvements du navires et les prédictions sur les charges de mer.

J.M. Chuang and Qin Tu; 2004; User's Manual of Interactive Software for Predicting CPF Bow-Flare Impulsive Loads; DRDC Atlantic CR 2004-183; R & D pour la défense Canada – Atlantique.

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1 Introduction

The software package, CPFSLAM, is for computing CPF bow-flare impulsive load on arbitrary cross section near CPF's bow when CPF re-enters the water in heavy seas. The NURBS (Non-Uniform Rational B-Spline) [1] is used to describe CPF hull form mathematically in terms of control polygon net which is then used to find the geometry of the cross section around bow for impulsive load computation. The numerical scheme for predicting CPF bow-flare impulsive load is based on desingularized Cauchy's formula, Gaussian quadrature and Euler-Lagrangian method [2] which are one of the most powerful numerical tools for solving time-domain nonlinear wave problems.
Based on Qt (GUI-toolkits) [3] and OpenGL (3-D rendering library) [4], an interactive GUI (Graphical User Interface) is developed for this software package. The GUI consists of 4 main parts, i.e.

1. Visualization of 3-D hull form,
2. Numerical validation of container problem
3. Numerical validation of wedge water entry problem
4. Numerical computation of CPF bow-flare impulsive load
   (a) Interactive selection of CPF's cross sections.
   (b) Interactive visualization for 2-D pressure distribution and free surface elevation.
   (c) Interactive visualization for 3-D pressure distribution and free surface elevation.

These four part are described in detail in the following sections.

2 Menu

2.1 File Menu

The *file* menu shown in Fig. 1 is used to quit the program. The *New*, *Open*, *Save* and *Save as* buttons are reserved for the future use.

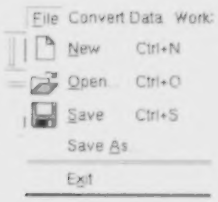

Figure 1: *File Menu*

2.2 Convert Data Menu

The *Convert Data* menu only has one submenu *Binary data* shown in Fig. 2, which is used to change ASCII data to binary data, because the system read binary data faster than ASCII data.

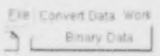

Figure 2: *Convert Data Menu*

2.3 WorkSpace Menu

The *WorkSpace Menu* shown in Fig. 3 is used to selected display model (Lines, Container, Wedge, CPF, CPF(2D) and CPF(3D)).
Notice that CPF, CPF(2D) and CPF(3D) workspaces are for interactive selection of CPF's cross section, visualization of 2-D and 3-D pressure distribution and free surface elevation, respectively.

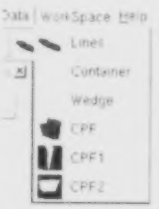

Figure 3: *Workspace Menu*

2.4 Help Menu

The *Help* menu shown in Fig. 4 is used to show the information.

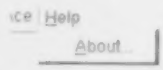

***Figure 4**: Help Menu*

3 ToolBar

Figure 5: *Toolbar*

The icons shown on Toolbar are described as follows:

1. : Show 3-D hull.
2. : Show container.
3. : Show wedge.
4. : Show CPF(G).
5. : Show CPF(2D).
6. : Show CPF(3D).

4 Animation Control Buttons

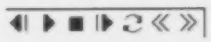

Figure 6: *Animation Control Button*

The animation control buttons are used as follows:

1. Rewind

   : Click once to return to the previous frame.

2. Play

: Plays an animation from the beginning or from where you paused it. (becomes Pause button when active.)

3. Pause

II : Pauses playback of the animation. (Becomes Play button when paused.) Press Play button to resume where animation left off.

4. Forward

: Click once to advance to the next frame.

5. Stop

_____: Stops playback and resets the animation to the beginning.

6. Cycle

: Repeat playing animation.

7. Slow

: Prolong the interval time between frames.

8. Fast

_____: Reduce the interval time between frames.

5 Mouse Operation

5.1 Pan View

In model area, hold down the left and right mouse buttons and drag it is to translate the scene in the x- and y- direction.

5.2 Zoom

The wheel of the mouse is used to zoom in (forward move) and zoom out (backward move).

5.3 Rotate

In model area, hold down the left mouse button and drag left and right is to rotate the view point around z-axis, or drag up and down to rotate the view point around y-axis.

6 Lines WorkSpace

This workspace is used to show the CPF's lines and visualization of its 3-D Hull.

6.1 Show

The *Show* button is used to show 3 plans and a 3-D view of CPF, as shown in Fig. 7

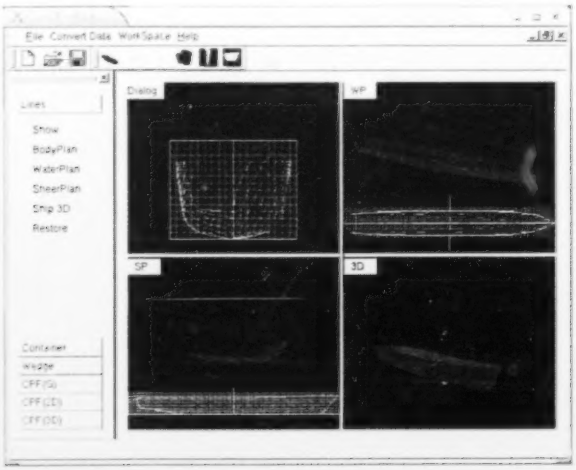

Figure 7: *Show*

6.2 BodyPlan

The *BodyPlan* button is for displaying the section lines in full screen, as shown in Fig. 8.

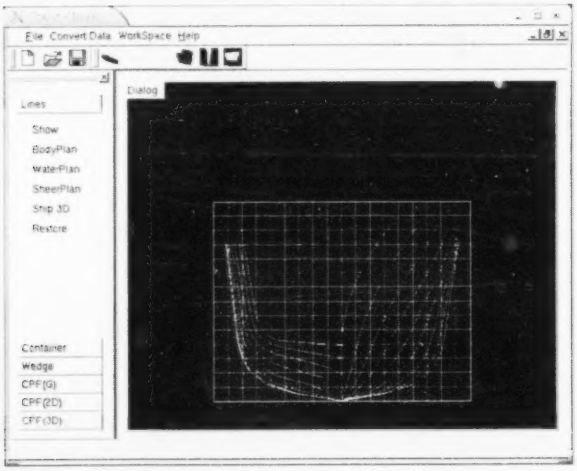

Figure 8: *BodyPlan*

6.3 WaterPlan

The *WaterPlan* button is for displaying the water lines in full screen, as shown in Fig. 9.

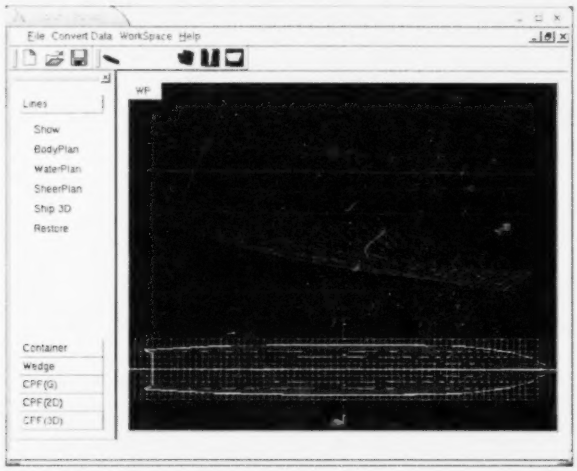

Figure 9: *WaterPlan*

6.4 SheerPlan

The *SheerPlan* button is for displaying the sheer lines in full screen, as shown in Fig. 10.

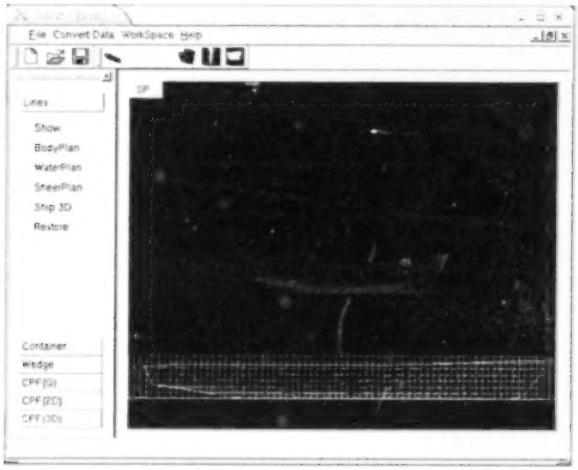

Figure 10: *SheerPlan*

6.5 Ship 3D

The *Ship 3D* button is for displaying the 3-D hull in full screen, as shown in Fig. 11.

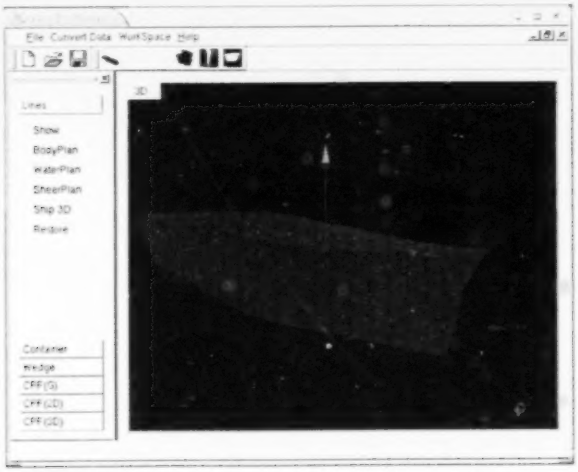

Figure 11: *Ship 3D*

6.6 Restore

The *Restore* button is to restore the view created by *show* button, as shown in Fig. 12.

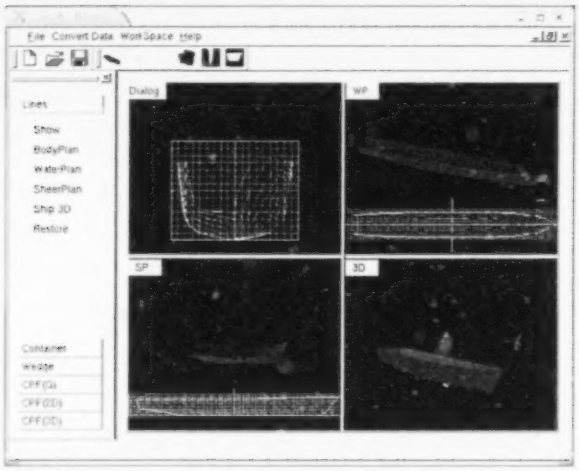

Figure 12: *Restore*

6.7 Change of Bodyplan

The number of section lines and the number of points on each section line can be changed from a dialog box, as shown in Fig. 13.

7 Container WorkSpace

The container problem is adopted in this software package to validate the time-marching scheme used in solving time-domain nonlinear wave problem. There are three numerical time-integration methods are used, namely, Euler, Second-Order and Runge-Kutta methods. The container workspace shown in Fig. 14 is used for choosing time marching scheme as well as the computation of analytical solution of the linear problem for the comparison purpose. The user can input the total time span and time step, i.e. Δt in terms of second, interactively, as shown in Fig. 16, 18 and 20.

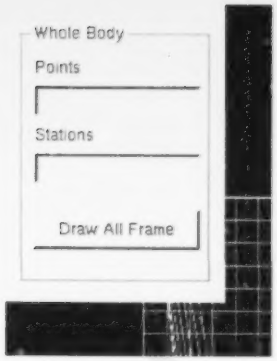

Figure 13: *Change BodyPlan*

7.1 Show Container

The *Show* button created four screens, namely, Exact solution, Euler, Second-Order and Runge-Kutta animations as shown in Fig. 14 .

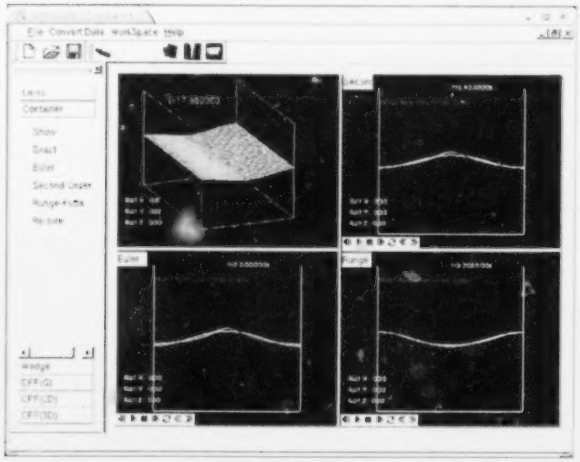

Figure 14: *Show Container*

7.2 Exact

The *Exact* button animates the exact solution in full screen, as shown in Fig. 15.

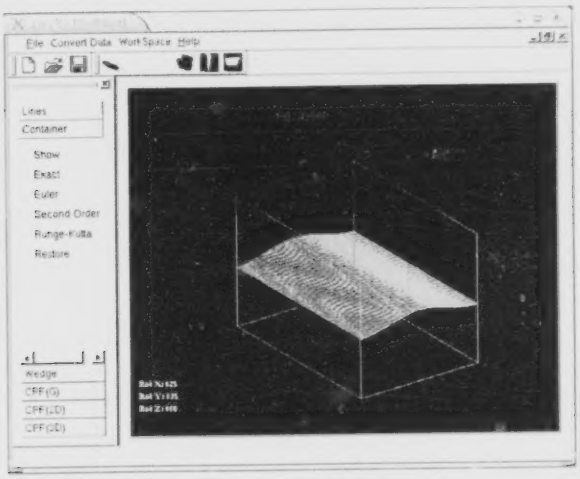

Figure 15: *Show Exact*

7.3 Euler

The *Euler* button is used to do the real time computation and animation as shown in Fig. 16 & 17, respectively.

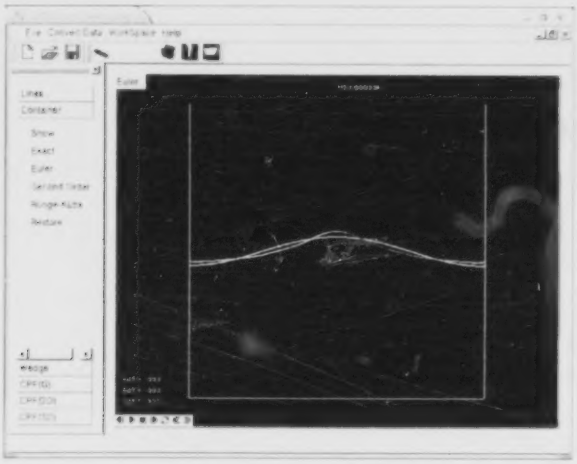

Figure 16: *Show Euler*

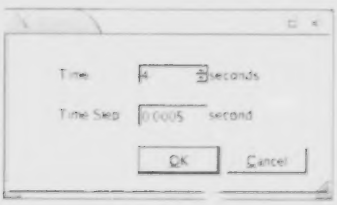

Figure 17: *Input Dialog of Euler Method*

7.4 Second-Order

The *Second-Order* button is used to do the real time computation and animation as shown in Fig. 18 & 19, respectively.

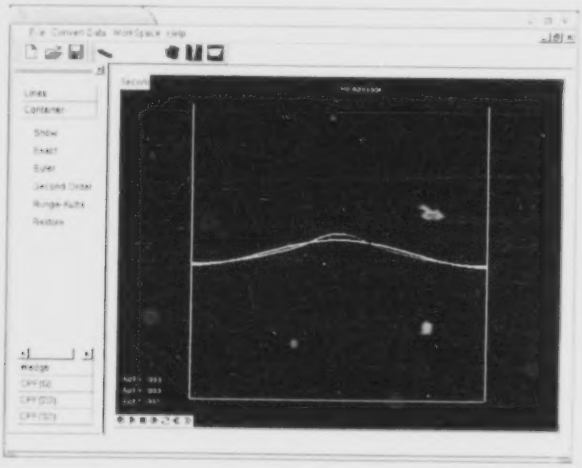

Figure 18: *Show Second-Order*

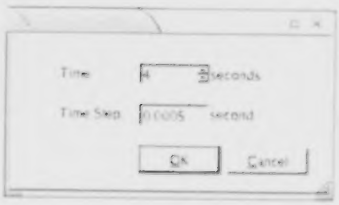

Figure 19: *Input Dialog of Second Order Method*

7.5 Runge-Kutta

The *Runge-Kutta* button is used to do the real time computation and animation as shown in Fig. 20 & 21, respectively.

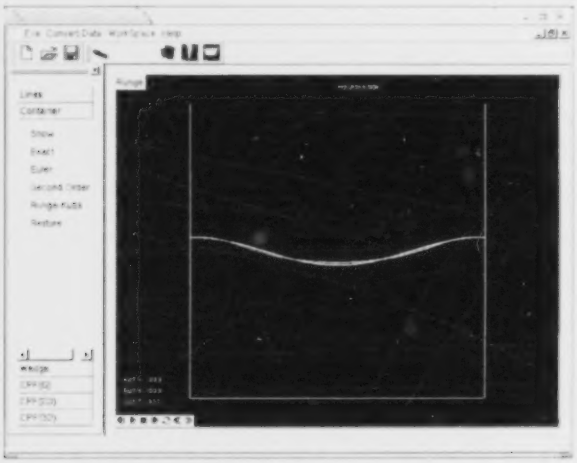

Figure 20: *Show Runge-Kutta*

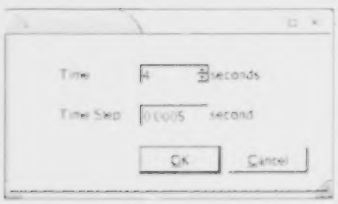

Figure 21: *Input Dialog of Range Kutta Method*

8 Animation of Wedge Water Entry Problem

8.1 Show

The *Show* button creates 2-D & 3-D animation of wedge entry problem for the deadrise angle $\alpha = 60^o$ and 45^o respectively as shown in Fig. 22.

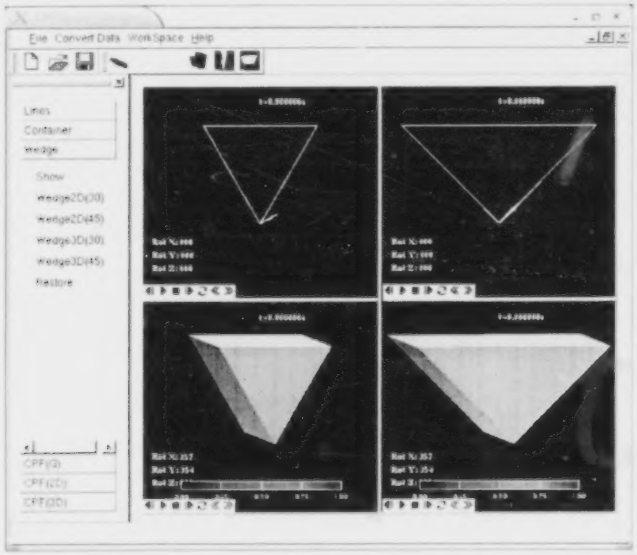

Figure 22: *Show Wedge Water Entry*

8.2 Wedge2D(30)

The *Wedge2D(30)* button animates the fine surface elevation and pressure distribution of wedge ($\alpha = 30^o$) entry problem, as shown in Fig. 23.

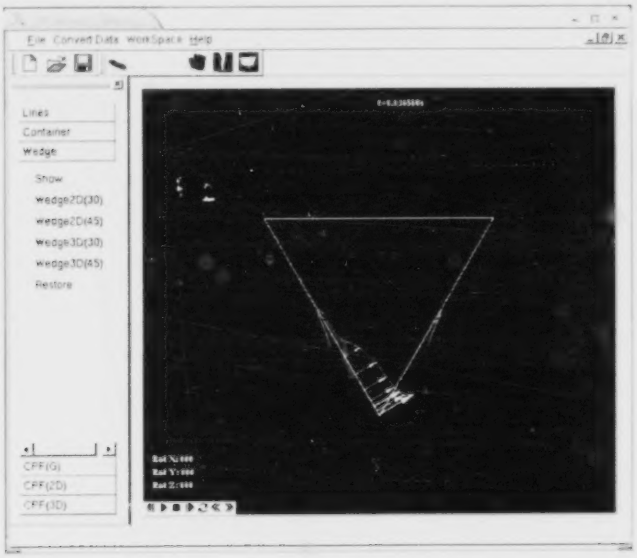

Figure 23: *Wedge2D(30)*

8.3 Wedge2D(45)

The *Wedge2D(45)* button animates the fine surface elevation and pressure distribution of wedge ($\alpha = 45^o$) entry problem, as shown in Fig. 24.

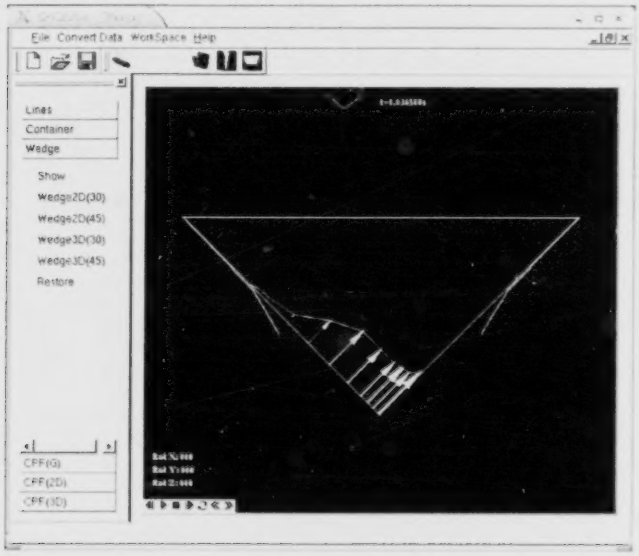

***Figure 24**: Wedge2D(45)*

8.4 Wedge3D(30)

The *Wedge3D(30)* button shows the 3-D view of animation of wedge ($\alpha = 30^o$) entry problem, as shown in Fig. 25.

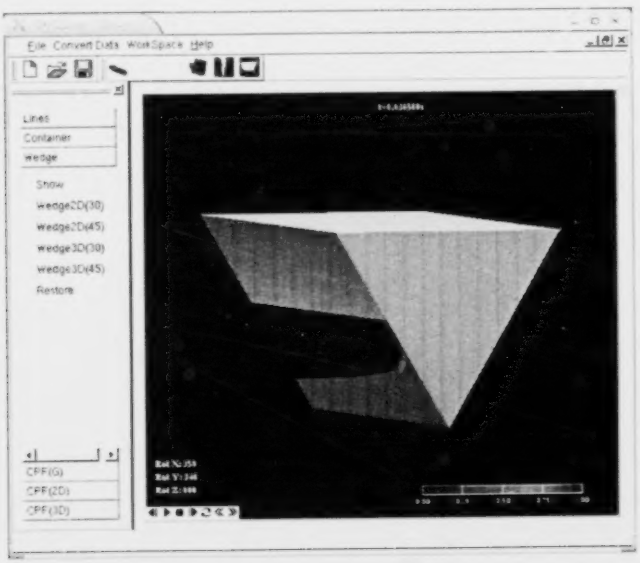

Figure 25: *Wedge3D(30)*

8.5 Wedge3D(45)

The *Wedge3D(45)* button shows the 3-D view of animation of wedge ($\alpha = 45^o$) entry problem, as shown in Fig. 26.

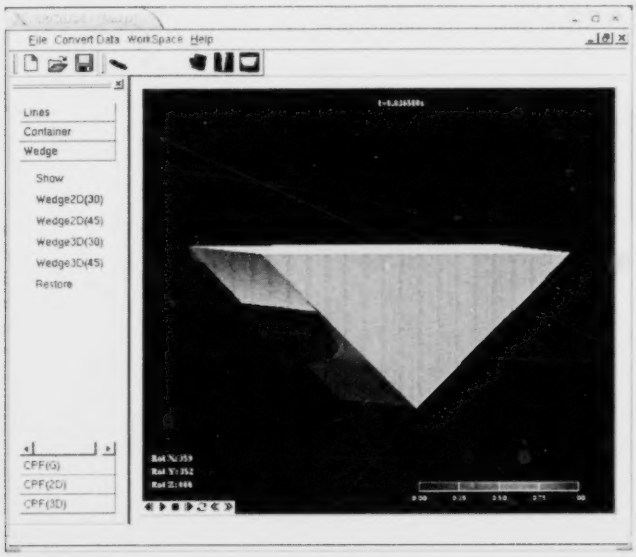

***Figure 26**: Wedge3D(45)*

8.6 Restore

The *Restore* button is to restore the view created by *show* button, as shown in Fig. 22.

9 Prediction of Bow-Flare Impulsive Load of CPF

9.1 CPF(G)

This workspace is used to select different portion of CPF for the computation of impulsive load.

9.1.1 Show

Show button shows the CPF's body plan, profile for the full body and lines and 3-D view of the selection portion for impulsive load computation.
Notice that the user can select different portion of the body for computation, just press the mouse at desired starting location and drag to the last location, then release the mouse. The lines and 3-D view of this portion will be popped up at the lower screen.

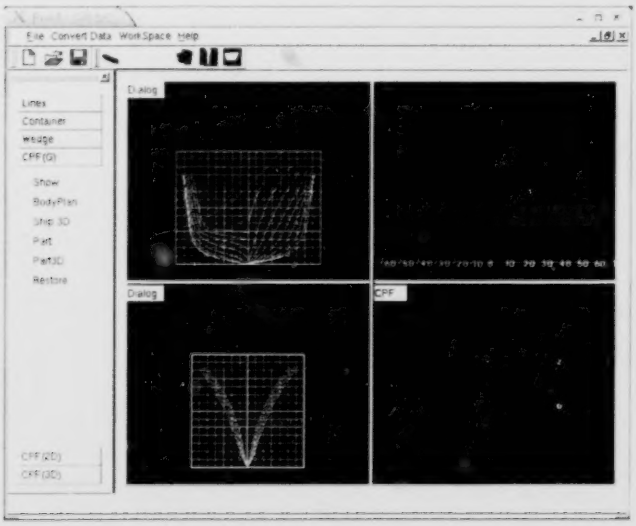

Figure 27: *Show CPF(G)*

9.1.2 BodyPlan

BodyPlan button shows the CPF's lines on full screen.

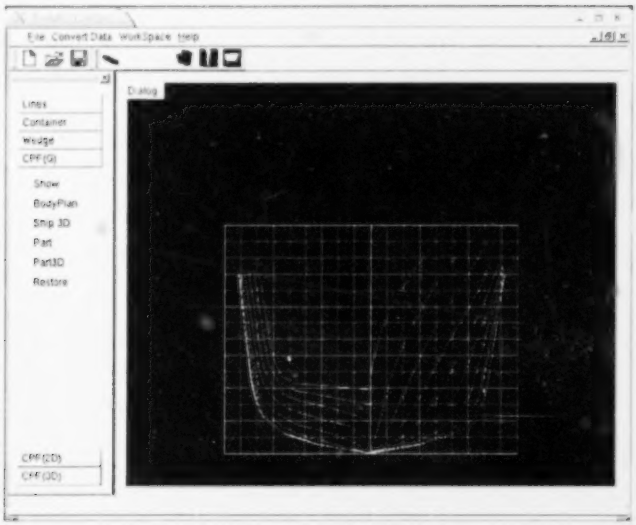

Figure 28: *Show BodyPlan*

9.1.3 Ship 3D

Ship3D button is to show CPF's profile on full screen for selection of body part to compute impulsive load.

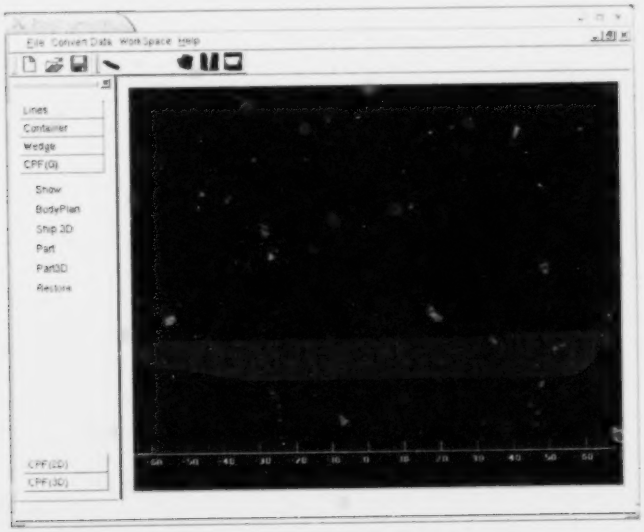

Figure 29: *Show 3D Ship*

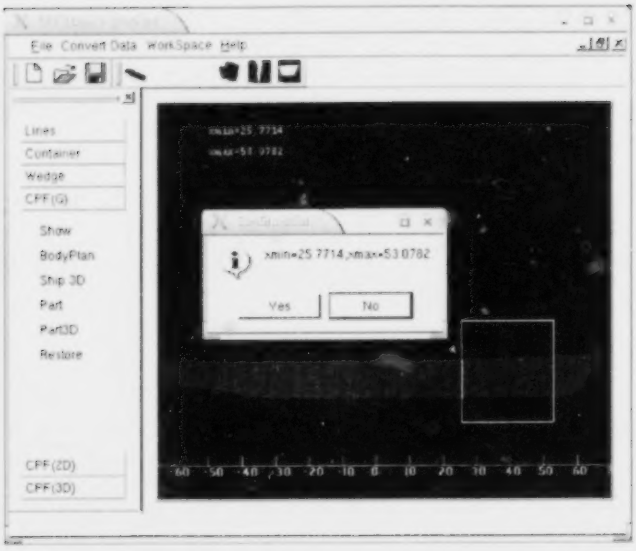

Figure 30: *Select Sections Using Mouse*

9.1.4 Part

Part button shows the lines of selected part of CPF on full screen.

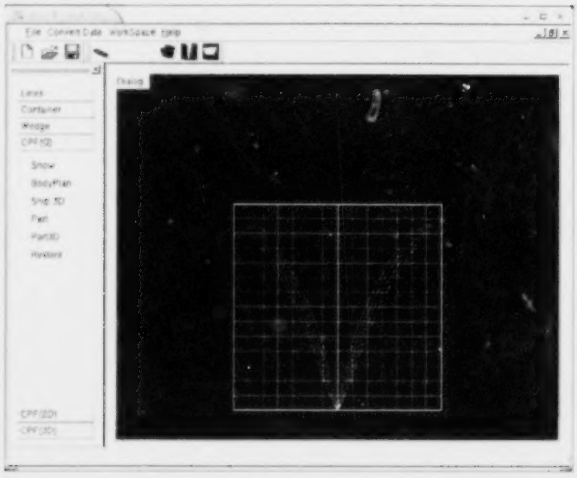

Figure 31: *Show Part*

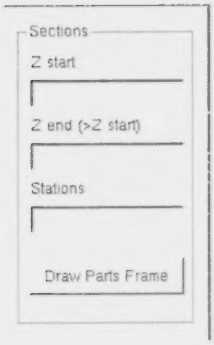

Figure 32: *Select Sections*

9.1.5 Part3D

Part3D button is to show 3-D body of the selection part. It can be shown either in solid or mech models as shown in Fig. 34 and 35, respectively.

1. Select Solid or Frame:

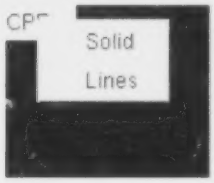

Figure 33: *Select Solid or Frame*

2. Solid

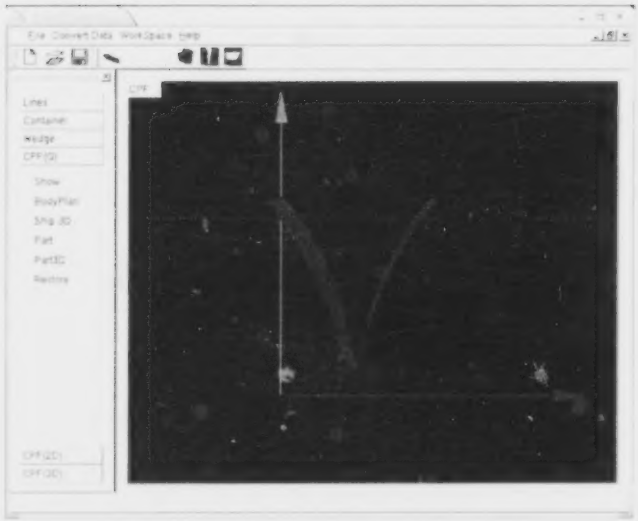

Figure 34: *Show 3D Part (solid)*

3. Frame:

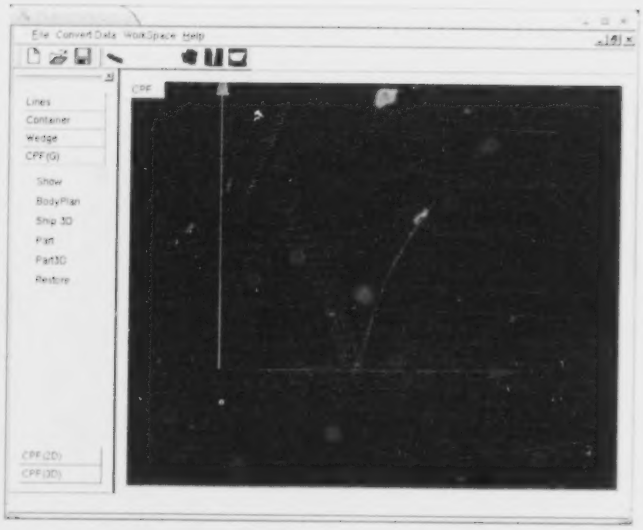

Figure 35: *Show 3D Part(Frame)*

9.1.6 Restore

The *Restore* button is to restore the view created by *show* button.

9.2 CPF(2D)

CPF(2D) is to animate and visualize the computational results of 2-D pressure distribution and free surface elevation of each 2-D section.

9.2.1 Show

Show button shows geometries of the selected sections with pressure distributions and free surface elevation when sections enter the water.

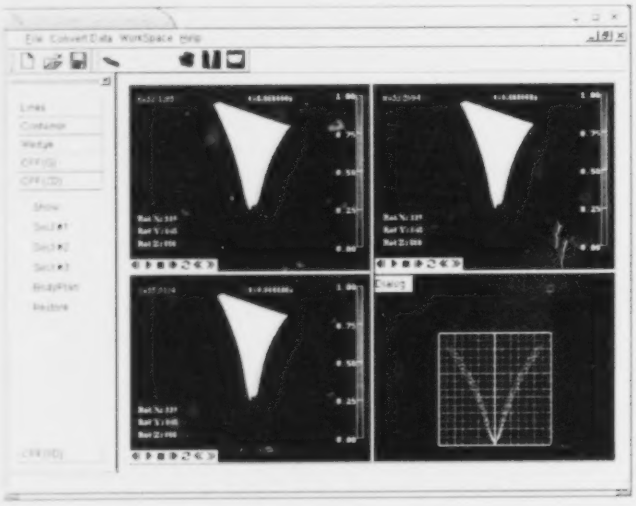

***Figure 36**: Show CPF(2D)*

9.2.2 Section #1

Section #1 button shows the geometry, pressure distribution and free surface elevation of the first section on full screen.

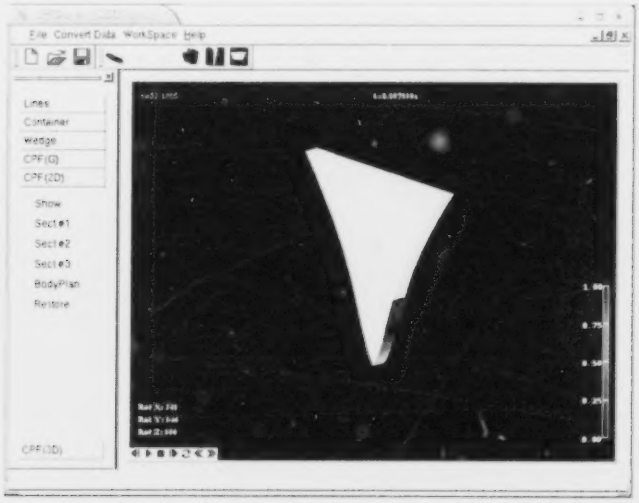

***Figure 37**: Show Section 1*

9.2.3 Section #2

Section #2 button shows the geometry, pressure distribution and free surface elevation of the second section on full screen.

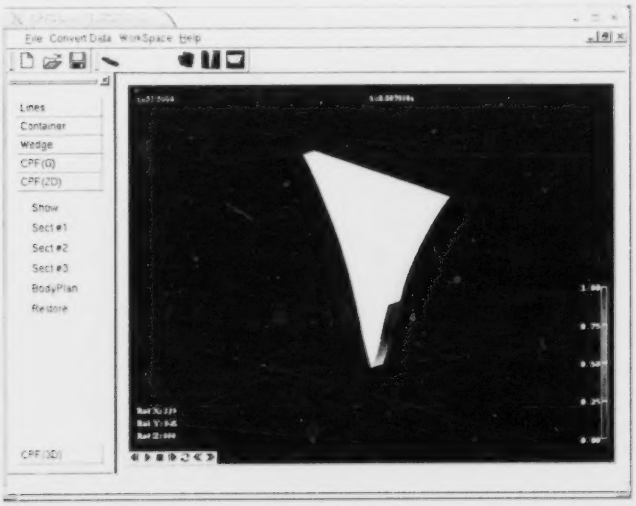

Figure 38: *Show Section 2*

9.2.4 Section #3

Section #3 button shows the geometry, pressure distribution and free surface elevation of the third section on full screen.

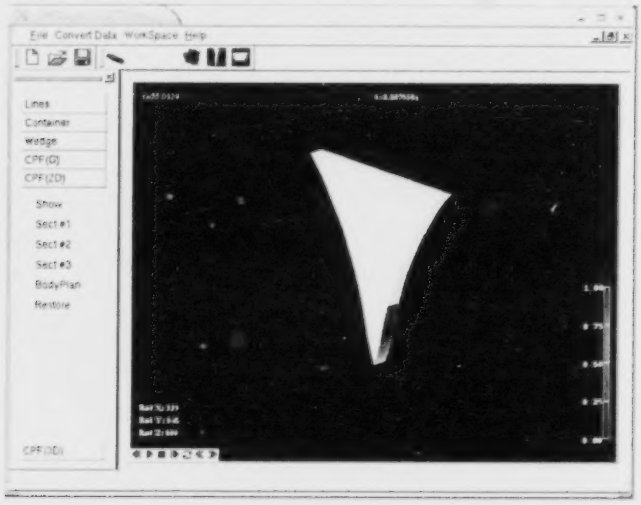

***Figure 39**: Show Section 3*

9.2.5 BodyPlan

BodyPlan button shows the CPF's lines on full screen.

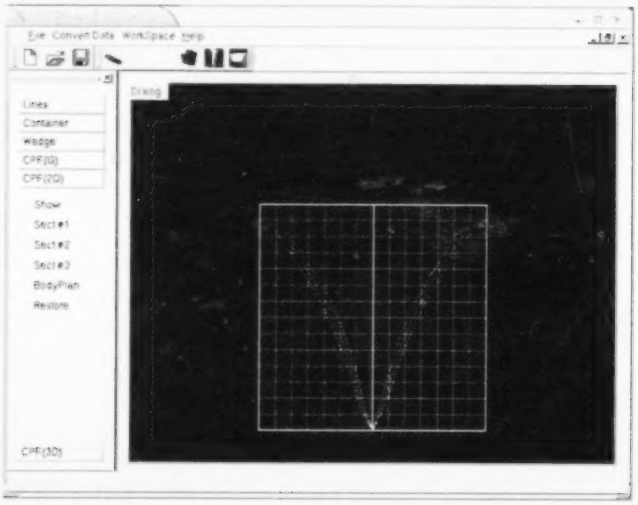

Figure 40: *Show BodyPlan*

9.2.6 Restore

The *Restore* button is to restore the view created by *show* button.

9.3 CPF(3D)

CPF(3D) is used to show the 2-D computational results of three different sections in 3-D view.

9.3.1 Show

Show button is to show the 3-D view of geometry, pressure distribution and free surface elevation of the computational results for 3 CPF's different sections.

Figure 41: *Show CPF(3D)*

9.3.2 Frame without Water Surface

Frame without water surface is to animate the pressure distribution on the surface of selected portion of CPF's body.

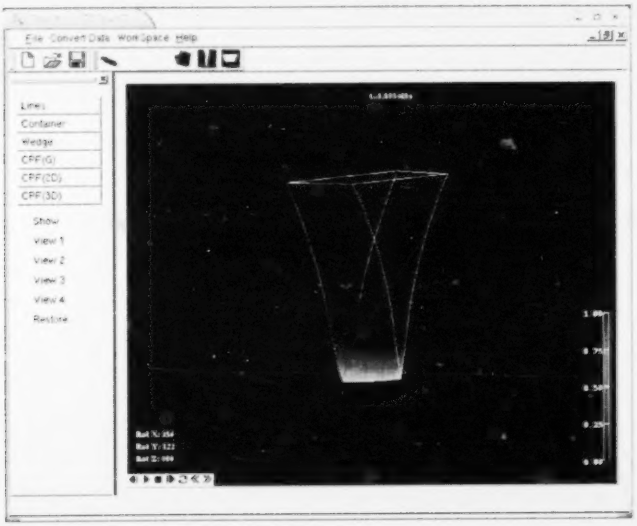

Figure 42: *Show Frame without Water Surface*

9.3.3 Frame with Water Surface

Frame with water surface is to animate the pressure distribution as well as free surface elevation on the surface of selected portion of CPF's body.

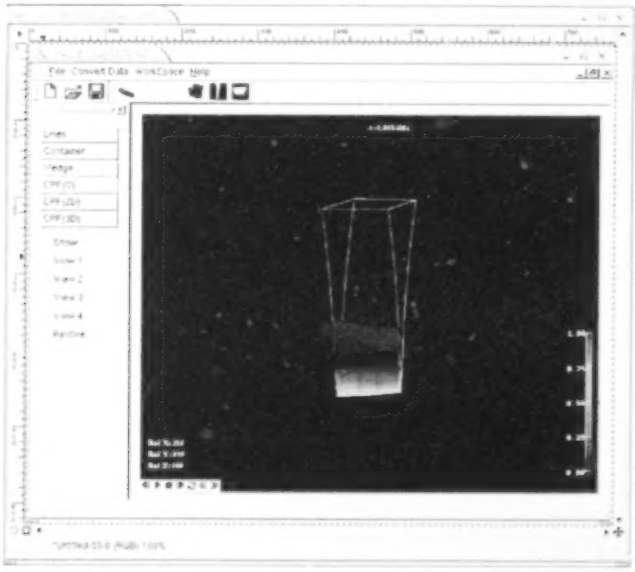

Figure 43: *Show Frame with Water Surface*

9.3.4 Solid without Water Surface

Solid without water surface is to animate the pressure distribution on the surface of selected portion of CPF's body.

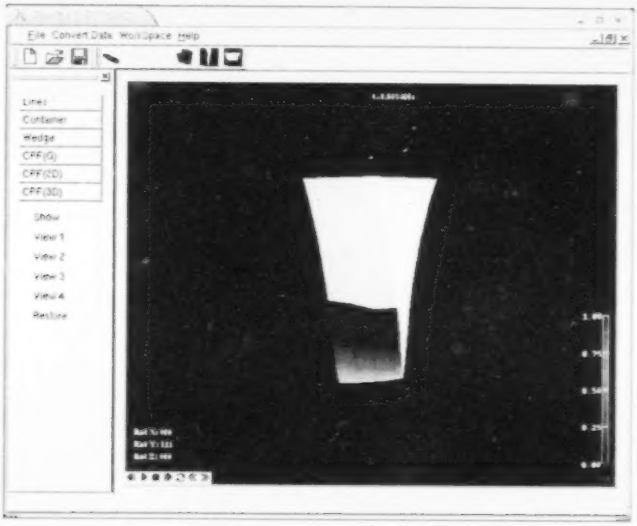

Figure 44: *Show Solid without Water Surface*

9.3.5 Solid with Water Surface

Solid with water surface is to animate the pressure distribution as well as free surface elevation on the surface of selected portion of CPF's body.

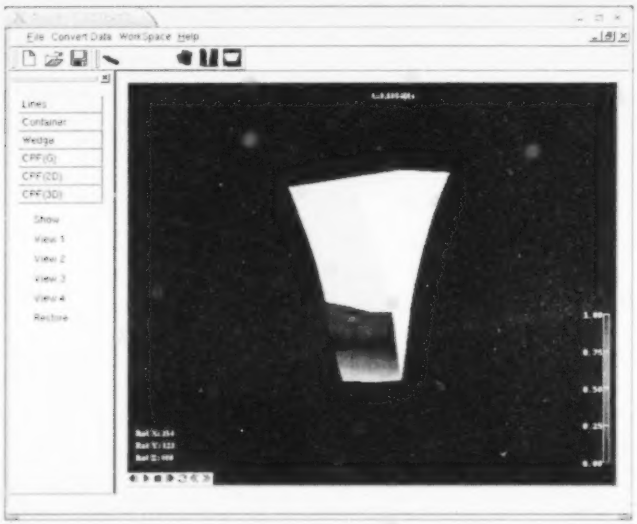

Figure 45: *Show Solid with Water Surface*

9.3.6 Restore

The *Restore* button is to restore the view created by *show* button.

10 Conclusions and Remarks

A interactive GUI is developed for CPFSLAM, a software package to predicting CPF bow-flare impulsive load. To validate our computational scheme, two simple cases, namely,

1. nonlinear transient wave in a rectangular contain, and;
2. wedge water entry problem,

are solved and simulated numerically in this software package.

The geometry of the sections around CPF's bow area are obtained very accurately from the global surface fitting of the CPF's offsets with NURBS. The pressure distribution over CPF's bow-flare and free surface elevation are animated with 2-D and 3-D view in the time domain.

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Based on the theoretical background, the numerical scheme and computational result for predicting CPF bow-flare impulsive loads, an interactive software package, namely, *CPFSLAM*, is developed. This package fully utilizes the special features of Qt (GUI-toolkits) and OpenGL (3-D rendering library). The software can predict flow and pressures arising from slamming of two-dimensional sections of the HALIFAX class. The software includes a three-dimensional NURBS representation of the HALIFAX class, from which the user can select a two-dimensional section of interest for slamming calculations.

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